INDOOR AIR QUALITY ASSESSMENT
Carbon Monoxide/Soot Investigation

Augustine Belmonte Middle School
25 Dow Street
Saugus, Massachusetts

Prepared by:
Massachusetts Department of Public Health
Bureau of Environmental Health Assessment
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Background/Introduction

At the request of Kevin Nigro, Director of Operations, Saugus Inspectional Services, and Deborah Rosati of the Saugus Health Department an indoor air quality assessment was done at the Augustine Belmonte Middle School in Saugus, Massachusetts. This assessment was conducted by the Massachusetts Department of Public Health (MDPH), Bureau of Environmental Health Assessment (BEHA). Concerns about carbon monoxide (CO) exposure and soot resulting from an incident with the school's mechanical plant prompted this request.

On February 14, 2002 a visit was made to this building by Cory Holmes, Environmental Analyst for BEHA's ER/IAQ program. Principal Anthony DiGregorio; David Jackson and Fred Rossi of the Saugus School Committee; and representatives of Servicemaster, a professional cleaning and restoration firm, accompanied Mr. Holmes. BEHA staff previously visited the school on February 1, 2000 to conduct a general indoor air quality assessment. A report was issued on March 5, 2000 (MDPH, 2000) which described the conditions of the building at that time and gave recommendations concerning remediation of conditions noted in the building. This report outlines our evaluation of remediation efforts concerning the recent CO and soot release and lists recommendations that BEHA believes should be implemented as soon as possible. A separate report detailing BEHA's general indoor air quality findings is in preparation and will be issued at a later date.

On February 1, 2002 the Saugus Fire Department (SFD) responded to reports of elevated CO levels and complaints of headache and nausea at the Augustine Belmonte Middle School. The SFD reportedly recorded CO levels of up to 98 PPM in the kitchen area around an electrical receptacle. Accumulations of soot in the boiler room and in surrounding occupied areas were also observed (SFD, 2002). Building occupants were relocated to other areas of the building while the building was ventilated and the town's service contractor was contacted to examine the boiler plant. The soot problem reportedly recurred on Monday, February 11, 2002 (Saugus, 2002).

Town officials have hired a consulting engineering firm to investigate the problem and design a solution. In addition, the SFD is reportedly conducting CO monitoring twice daily. The Massachusetts Department of Labor and Workforce Development (MDLWD), Division of Occupational Safety (DOS) was also contacted and sent an enforcement letter which recommended the following actions be taken by the Saugus School Department: 1) installation of a new CO monitor in the cafeteria, 2) provide a time line for plans to upgrade the furnace room (including improving make up air and flue space for the removal of products of combustion), 3) discontinue the testing of emergency generator during periods of occupancy, and 4) consideration of relocation of the emergency generator outdoors (MDLWD, 2002).

Details describing the source of the furnace problem were detailed in correspondence between the Town of Saugus Inspectional Services Department and the Commonwealth of Massachusetts Executive Office for Administration and Finance, Division of Capital Assets Management. This correspondence is included as an attachment. The source of soot is attributed to a back up of exhaust combustion products through breaches in the deteriorated chimney liner. The chimney currently serves as an exhaust for the emergency generator, two water heaters, the incinerator and two boilers. Saugus town officials and their consultant concluded that this equipment running simultaneously was the most likely source of soot backed up through cracks, crevices and other breaches of the chimney/flue. The deterioration of the chimney liner in combination with the undersized chimney flue, insufficient make up air and certain wind and weather conditions, overwhelms the ability of the chimney to exhaust products of combustion from the boiler room causing a back up of soot (see Picture 1) and other combustion products (Saugus, 2002).

A second potential CO source was identified in the kitchen area. Located in the center of the kitchen are a number of gas fired kitchen appliances (e.g., ovens, stoves, fryolators) installed beneath a vent hood (see Picture 2). School/town officials stated that at the time of the CO incident the vent hood was not operational. BEHA staff confirmed that this vent has since been repaired and was operating during the assessment. However, the vent hood was intended to provide exhaust ventilation for kitchen equipment that was present when the kitchen was first opened. Over the years more equipment has been added without the modification/adjustment of exhaust capabilities.

Prior to the BEHA assessment, school and town officials had reportedly already taken a number of remedial measures. To avoid overloading of combustion products into the chimney flue an automatic lock-out control has been installed on the boiler system allowing only one boiler to run at a time. Oil burners were also serviced to ensure proper mixing of air/fuel. Testing and operation of the emergency generator during school hours has been discontinued. Some gas-fired kitchen equipment is now discontinued and a new wall-mounted CO monitor was installed in the kitchen (see Picture 3). Finally, floor penetrations, and cracks and crevices in the chimney and boiler room, have been sealed to prevent the migration of combustion products into occupied areas (see Picture 4). Daily inspections from the SFD continue to identify any additional pathways of pollutant migration (Saugus, 2002).

The emergency procurement waiver includes the following activities: removal and replacement of combustion fueled equipment, the removal of deteriorated sections of the chimney, the installation of a new flue, installation of a new emergency generator exhaust flue independent of the boiler/hot water flue; and an increase in the kitchen exhaust fan capacity (Saugus, 2002).

At the time of our inspection, BEHA staff were informed by school officials that the emergency procurement waiver had been approved. The Town of Saugus was in the process of soliciting bids for the work. Servicemaster Inc. was contracted by the school department's insurance agent to conduct clean-up/restoration operations in areas of the school impacted by the soot release. As part of the remediation effort, Covino Associates (Covino), an environmental engineering firm, will conduct sampling prior to the Servicemaster Inc. clean up to establish a baseline and characterize the presence of soot in occupied areas. Upon completion of the clean up, Covino will conduct clearance testing to determine the efficacy of remediation efforts.

Methods

Air tests for carbon monoxide were taken with the TSI, Q-Trak, IAQ Monitor, Model 8551. Air tests for ultrafine particulates were taken with the TSI, P-Trak ™ Ultrafine Particle Counter, Model 8525.

Results and Discussion

It is important to note that the kitchen/cafeteria are located directly above the boiler plant on the second floor. In order to explain how boiler room pollutants may be impacting adjacent areas, the following concepts concerning heated air and creation of air movement must be understood.

- Heated air will create upward air movement (called the stack effect).
- Cold air moves to hot air, which creates drafts.
- As heated air rises, negative pressure is created, which draws cold air to the equipment creating heat.
- Combusted fossil fuels contain heat, gases and particulates that will rise in air. In addition, the more heated air becomes the greater airflow increases.
- The operation of ventilation equipment (e.g., kitchen vent hood) can create negative air pressure, which can draw air and pollutants from the loading dock/boiler room.

Each of these concepts has influence on the movement of combustion products. BEHA staff conducted air monitoring to assess whether contaminants generated by the boiler plant were migrating into occupied areas of the building. Measurement for ultrafine particles (UFPs) produced in soot generation, in combination with carbon monoxide measurements, were used to identify potential pathways of combustion products. These results are listed in Tables 1-3.

The use of fossil fuel-powered equipment (e.g., oil burners, cooking appliances, diesel or gasoline-powered vehicles) can produce carbon monoxide. Using carbon monoxide solely to detect sources of combustion pollutants has limitations. If the source of combustion pollutants is allowed to dilute in a large volume of air within a building, carbon monoxide concentrations may decrease below the detection limits of equipment. The process of combustion produces airborne liquids, solids and gases (NFPA, 1997). The measurement of airborne particulates, in combination with carbon monoxide measurements can be used to pinpoint the source of combustion products and identify pathways of migration. Measurements for UFPs [particles measuring 0.02 micrometers (μm) to 1 μm in diameter] were made as well as measuring carbon monoxide levels.

The process of combustion produces a number of pollutants, depending on the composition of the material. In general, common combustion emissions can include carbon monoxide, carbon dioxide, water vapor and smoke. Of these materials, carbon monoxide can produce immediate, acute health effects upon exposure. The MDPH established a corrective action level concerning carbon monoxide in ice skating rinks that use fossil-fueled ice resurfacing equipment. If an operator of an indoor ice rink measures a carbon monoxide level over 30 ppm, taken 20 minutes after resurfacing within the rink, that operator must take actions to reduce carbon monoxide levels (MDPH, 1997).

The US Environmental Protection Agency has established National Ambient Air Quality Standards (NAAQS) for exposure to carbon monoxide in outdoor air. Carbon monoxide levels in outdoor air must be maintained below 9 ppm over a twenty-four hour period in order to meet this standard (US EPA, 2000). No carbon monoxide measurements exceeded the NAAQS during the BEHA assessment (see Table 1). The highest reading obtained was 7 ppm in the boiler room.

The combustion of fossil fuels can produce particulate matter that is of a small diameter (<10 μm), which can penetrate into the lungs and subsequently cause irritation. For this reason a device that can measure particles of a diameter of 10 μm or less was also used to identify pollutant pathways from the boiler room into occupied areas. Inhaled particles can cause respiratory irritation.

The instrument used by the BEHA to conduct air monitoring for UFPs counts the number of particles that are suspended in a cubic centimeter (cm^3) of air. This type of air monitor is useful as a screening device, in that it can be used as a tracker to identify the source of airborne pollutants by counting the actual number of airborne particles. The source of particle production can be identified by moving the ultrafine particle counter (UPC) through a building towards the highest measured concentration of airborne particles. Measured levels of particles/cm^3 of air increases as the UPC is moved closer to the source of particle production. While this equipment can ascertain whether unusual sources of ultrafine particles exist in a building or that particles are penetrating through spaces in doors or walls, it cannot be used to quantify whether the NAAQS PM_{10} standard was exceeded. The primary purpose of these tests at the school was *to identify and reduce/prevent pollutant pathways*. Air monitoring for ultrafine particles was conducted in the boiler room, areas adjacent and above the boiler room and around doors, utility holes, wall cracks and other areas, which may be directly impacted from close proximity to the boiler room. For comparison, measurements in areas away from the boiler room, believed not to be effected, were also conducted. The highest reading for ultrafine particulates was measured within in the boiler room. Measurements recorded over outside (background) levels indicate a combustion source of UFPs as the equipment in the boiler room.

Although a number of pathways have been eliminated, BEHA staff identified several other pathways for combustion products and pollutants to move from the boiler room into occupied areas on both the first and second floors. Several pathways were observed in the vestibule directly adjacent to the boiler room. The boiler room doors are not airtight, which allows dirt, dust and particulates to migrate into adjacent areas. The vestibule also serves as the loading dock for the cafeteria. Significant spaces were noted beneath the loading dock doors from which drafts were detected and light could be seen penetrating (see Picture 5). An abandoned electrical panel and a number of utility holes in the restroom ceiling (see Pictures 6 & 7) next to the loading dock were also found, which may also serve as potential pathways.

BEHA staff examined the chimney traversing the kitchen area and observed a metal panel with spaces around it that was not sealed (see Picture 8). Other potential pathways were identified in the slop room off the kitchen area, including the slop sink drain (see Picture 9) and the abandoned chute for the incinerator.

The most obvious pathway in which combustion products can travel from the boiler room into the kitchen area is via a dumbwaiter located in the loading dock area (see Picture 10). Products of combustion can enter the vestibule around the boiler room door. The loading dock becomes pressurized by drafts entering through spaces around the loading dock doors. When this area becomes pressurized, it can force combustion products through any available pathways that may be present (e.g., wall cracks, abandoned ductwork, utility holes). Further, once combustion products/odors are in the loading dock area they can be distributed to the second floor/kitchen area via the dumbwaiter shaft. The piston effect, created by dumbwaiter movement, can temporarily place the loading dock under negative pressure as the dumbwaiter moves upwards, subsequently enhancing the distribution of combustion products into occupied areas.

Each of these examples present pathways for air to move from the boiler room to occupied areas of the building, specifically the first floor corridor and kitchen area above the boiler room. To reduce airflow to the second floor kitchen area and the first floor corridor, elimination of these pollutant pathways should be considered.

Recommendations

In view of the findings at the time of the visit, the following recommendations are made:

1. Continue with plans to conduct structural repairs/replacement of flue (outlined in the Emergency Procurement Waiver) to prevent the possibility of future exposure to combustion products.
2. Continue with plans to hire a professional cleaning/restoration firm to conduct a thorough cleaning of areas impacted by boiler blow back.
3. Keep boiler room and loading dock doors closed at all times. Replace loading dock doors with tight-fitting doors that fit completely flush with threshold. Seal doors on all sides with foam tape, and/or weather-stripping.
4. Once improvements to provide sufficient make-up air to the boiler plant are made, consider replacing boiler room doors with tight-fitting doors that prevent airflow from the boiler room into adjacent areas. Consider installing weather-stripping/door sweeps on both sides of doors to provide a duel barrier. Ensure tightness of doors by monitoring for light penetration and drafts around doorframes.

5. Ensure vehicle engines are off during loading/unloading operations to prevent entrainment of vehicle exhaust.
6. Consider discontinuing use of dumbwaiter until boiler room improvements are made and boiler room and loading dock doors are replaced/sealed.
7. Ensure all utility holes and wall cracks are properly sealed to eliminate pollutant paths of migration. Consider contacting a plumber to inspect the slop room drain for integrity.
8. Consider removing incinerator and completely seal abandoned chute in slop room. If not removed, ensure abandoned chute is sealed airtight to prevent the migration of boiler room pollutants/odors into slop room.
9. Continue with plans to improve exhaust capabilities for kitchen equipment. Consider contacting a heating ventilation and air conditioning (HVAC) engineering firm specializing in proper food service/restaurant ventilation systems.

The work prescribed consists of a number of activities including demolition of building materials, which can generate dusts and odors. In addition to the steps previously noted, the following recommendations should be implemented in order to reduce the migration of renovation generated pollutants into occupied areas. We suggest that many of these steps be taken on any renovation project within a public building:

1. Develop a notification system for building occupants immediately adjacent to construction activities to report construction/renovation related odors and/or dusts

problems to the building administrator. Have these concerns relayed to the contractor in a manner to allow for a timely remediation of the problem.

2. Establish communications between all parties involved with building renovations to prevent potential IAQ problems. Develop a forum for occupants to express concerns about renovations as well as a program to resolve IAQ issues.

3. When possible, schedule projects which produce large amounts of dusts, odors and emissions during unoccupied periods or periods of low occupancy.

4. Disseminate scheduling itinerary to all affected parties, this can be done in the form of meetings, newsletters or weekly bulletins.

5. Obtain Material Safety Data Sheets (MSDS) for all construction materials used during renovations and keep them in an area that is accessible to all individuals during periods of building operations as required by the Massachusetts Right-To-Know Act (MGL, 1983).

6. Consult MSDS' for any material applied to the effected area during renovations including any sealant, carpet adhesive, tile mastic, flooring and/or roofing materials. Provide proper ventilation and allow sufficient curing time as per the manufacturer's instructions concerning these materials.

7. Use local exhaust ventilation and isolation techniques to control for renovation pollutants. Precautions should be taken to avoid the re-entrainment of these materials into the building's HVAC system. The design of each system must be assessed to determine how it may be impacted by renovation activities. Specific HVAC protection requirements pertain to the return, central filtration and supply components of the ventilation system. This may entail shutting down systems

(when possible) during periods of heavy construction and demolition, ensuring systems are isolated from contaminated environments, sealing ventilation openings with plastic and utilizing filters with a higher dust spot efficiency where needed (SMACNA, 1995).

8. Seal utility holes, spaces in roof decking and temporary walls to eliminate pollutant paths of migration. Inspect these areas regularly to ensure integrity is maintained.

9. If possible, relocate susceptible persons and those with pre-existing medical conditions (e.g., hypersensitivity, asthma) away from areas of renovations.

10. Implement prudent housekeeping and work site practices to minimize exposure to renovation pollutants. This may include constructing barriers, sealing off areas, and temporarily relocating furniture and supplies. To control for dusts, a high efficiency particulate arrestance (HEPA) equipped vacuum cleaner in conjunction with wet wiping of all surfaces is recommended.

11. Consider changing HVAC filters more regularly in areas impacted by renovation activities. Examine the feasibility of acquiring more efficient filters for these units.

References

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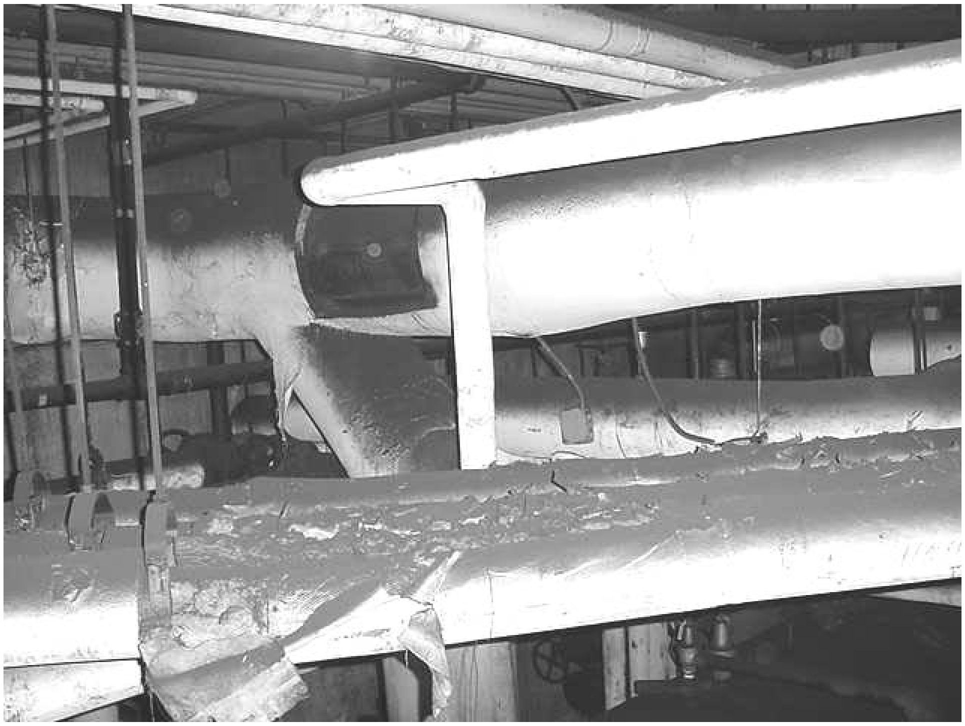
Picture 1



Soot Accumulation on Surfaces in Boiler Room

Picture 2

Gas Powered Appliances under Vent Hood in Kitchen

Picture 3

Wall-Mounted CO Detector

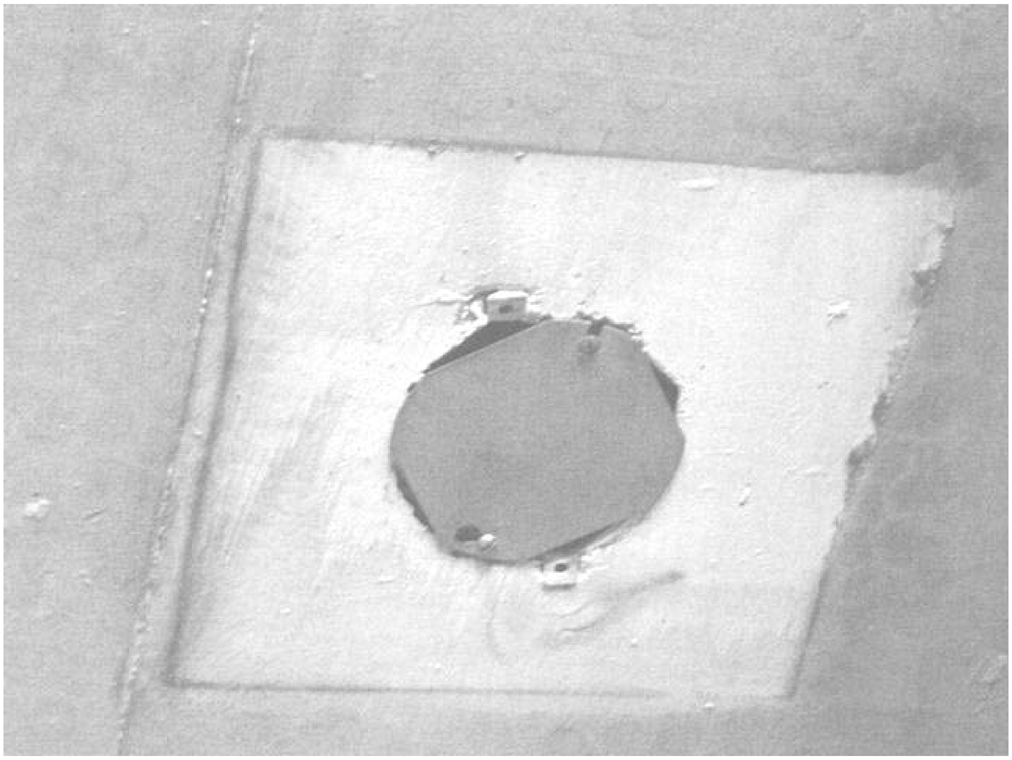
Picture 4

Sealed Wall Crack in Chimney

Picture 5

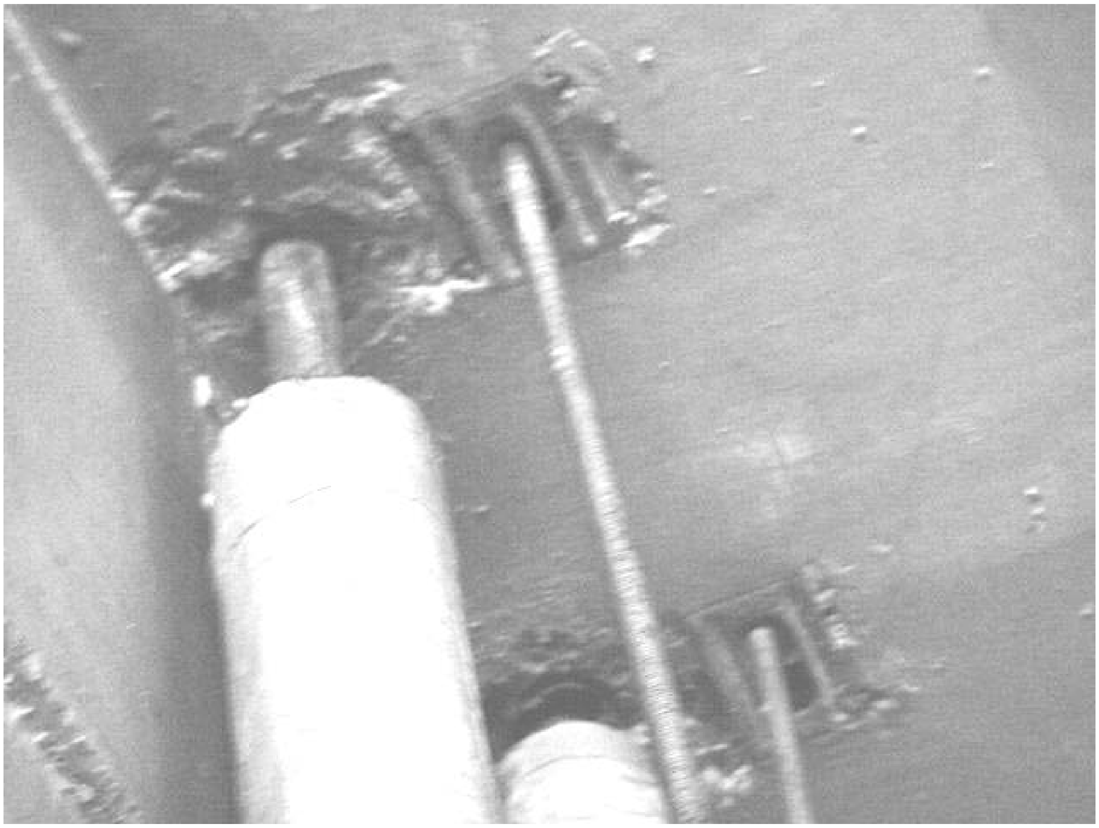
Spaces around Loading Dock Door Directly Adjacent to Boiler Room
Note Light Penetration

Picture 6



Abandoned Light Fixture in Restroom Ceiling Adjacent to Boiler Room, Note Spaces around Metal Plate

Picture 7



Utility Holes in Restroom Ceiling Adjacent to Boiler Room

Picture 8

Spaces around Access Panel in Kitchen Storeroom

Picture 9

Drain in Slop Room off Kitchen

Picture 10

Dumbwaiter Located in Loading Dock Area Adjacent to Boiler Room

TABLE 1

Indoor Air Test Results – Belmonte Middle School, Saugus, MA – February 14, 2002

Location	Carbon Monoxide *ppm	Ultrafine Particulates **p/cc	Comments
Outside (Background)	N= 0-1 S= 0-1 E= 0-1 W= 0	N= 29,000 S= 27,000 E=24,000 W=23,000	Weather conditions, clear, cold & sunshine, school parking lots (North/East/Southeast) Time: ~ 2:30 PM
Principal's Office	0	13,800	
Hallway Outside Boiler Room	0	47,000-71,500	
Loading Dock	4	129,000	Spaces/drafts around loading dock door, dumbwaiter
Boiler Room	7	235,000	Settled soot/dust
Restroom (adjacent to loading dock)	3	49,800	Utility holes, spaces around access plate (pathways)
Room 179 (wood shop)	0	31,700	Door open
Music	0	19,100	
Reading Classroom	0	16,200	

*** ppm = parts per million parts of air**
**** p/cc = particles per cubic centimeter of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred 600 - 800 ppm = acceptable > 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 2

Indoor Air Test Results – Belmonte Middle School, Saugus, MA – February 14, 2002

Location	Carbon Monoxide *ppm	Ultrafine Particulates **p/cc	Comments
Classroom 249, Consumer Science	0	92,800	Soot accumulation (stains) on honeycomb ceiling, electrical cooking appliances
Kitchen Storage Area	0	57,600	Dumbwaiter Terminus, cold drafts around dumbwaiter
Dumbwaiter (shut)	0	76,800	Readings taken around edges of dumbwaiter
Dumbwaiter (open)	0	91,000	Readings taken around edges of dumbwaiter
Slop Room (center)	0-1	78,000	
Floor Drain	0	103,000	
Incinerator Hatch	0	84,000	Sealed with metal cap
Kitchen (center)	0-1	50,000	
Appliance Block	0-1	47,000	After lunch, gas appliances not operating (w/exception of pilot lights), exhaust hood on
Electrical Panel (in kitchen)	0-1	33,000	

*** ppm = parts per million parts of air**
**** p/cc = particles per cubic centimeter of air**

Comfort Guidelines

Carbon Dioxide -	< 600 ppm = preferred
	600 - 800 ppm = acceptable
	> 800 ppm = indicative of ventilation problems
Temperature -	70 - 78 °F
Relative Humidity -	40 - 60%

TABLE 3

Indoor Air Test Results – Belmonte Middle School, Saugus, MA – February 14, 2002

Location	Carbon Monoxide *ppm	Ultrafine Particulates **p/cc	Comments
Metal Access Panel (near chimney)	0	47,000	
Cafeteria	0	17,500	
Library	0	10,8000	
Classroom 301	0-1	10,800	Exhaust off
Classroom 202	0	11,600	Door open
Classroom 214	0	12,500	
Classroom 112	0	12,700	Univent off
Classroom 102	0	13,000	Exhaust off

*** ppm = parts per million parts of air**
**** p/cc = particles per cubic centimeter of air**

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Carbon Dioxide -	< 600 ppm = preferred
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